MULTI-REEL APPARATUS IN A PAPER MACHINE

FIELD OF THE INVENTION

The present invention relates to papermaking machines, and more particularly relates to a method and apparatus for achieving a continuous paper winding process using a number of reel-up stations at different locations along a travelling paper web path wherein one station is always prepared to commence winding upon completion of the paper roll at another station.

BACKGROUND OF THE INVENTION

In the manufacture of various types of tissue products, such as facial tissue, bath tissue, paper towels and the like, the dried tissue web or sheet coming off of the tissue machine is initially wound into a parent roll and temporarily stored for further processing. Sometime thereafter, the parent roll is unwound and the sheet is converted into a final product form.

In a conventional dry end of a papermaking machine, the dried web is wound into rolls by the reel-up. The conventional reel-up includes a rotating reel shaft held by a pair of primary arms against a reeling drum to form a nip. The free end of the continuous paper web, in the form of a leader, is introduced into the nip. The paper web is adhered to the reel shaft by a vacuum tape or glue and winds onto the reel shaft as it is advanced into the nip to form a roll. Once partially wound, the primary arms transfer the roll to a set of secondary arms which complete the winding process. After the roll is completed, the continuous paper web is severed, the downstream portion of the web becoming the tail end that is wound onto the completed roll and the upstream portion becoming the new leader.

Completion of the roll frees the apparatus to receive a new reel shaft. A pair of lowering arms, positioned above the primary arms and the reeling drum, retrieve a new reel shaft from a stock of reel shafts and lower the new reel shaft into the primary arms.

The primary arms grippingly receive the new reel shaft and hold the new reel shaft against the reeling drum to form the nip. The new leader is advanced into the nip to begin a new roll.

Reel changing methods are commonly assisted by balloon blowing. Balloon blowing entails creating slack across the full width of the paper by somewhat retarding the finished roll. With the aid of compressed air, the fold thus formed is then forced into the nip between the new reel shaft and the reel drum, after which the paper web is cut off. The degree of control over the paper web in the balloon blowing procedure is relatively low because the web is not supported on any support in the ballooned portion of the web. This lack of control can lead to problems.

U.S. Patent No. 5,901,918 to Klerelid et al. ('918) addresses this lack of control by providing support for the paper web during reel switching. The apparatus disclosed by the '918 patent includes a reel-up having a fabric run defined by a flexible transfer belt spanning two support rolls. The flexible transfer belt supports and advances the paper web. The web is transferred from the transfer belt to a parent roll as the parent roll is urged against one portion of the flexible belt. Reel switching occurs when a new reel spool is lowered into an initial winding position against the web on another portion of the belt. No balloon blowing is used and the paper web is continuously supported. However, arms are required to lower the new reel spool into the initial winding position, and the new reel spool must be moved along the transfer belt from the initial winding position into a final winding position as winding proceeds. This movement of the building paper roll complicates the control of the nip load.

Another disadvantage of reel switching is the production down time associated with the reel switching process. The production of large jumbo rolls minimizes the frequency of reel switching. However, jumbo rolls are even more difficult to wind and handle due to their size and weight. The winding process typically starts when a core is brought into contact with a reel drum supporting the paper web. Controlling the linear load in the paper web at the nip during initiation of the winding process is made more

difficult by the heavy core shafts of the jumbo rolls. These difficulties continue as the roll is wound and its weight increases, because the tissue paper web is fragile and sensitive to the nip pressure. Conventional reel-ups require a complicated control system to control the linear load and meet requirements for tissue web quality when winding jumbo rolls. Manufacturing losses from these difficulties occur because the failure to control linear load often results in 200 to 300 meters of tissue paper web at the beginning of the jumbo roll not being of commercial quality.

Therefore, it would be advantageous to have a reeling apparatus that always supports the paper web and that minimizes any delay caused by the reel switching process. It would be further advantageous to have a reeling apparatus that produced smaller rolls without additional production down time.

SUMMARY OF THE INVENTION

These and other needs are met by the multi-reel apparatus according to the present invention. The present invention avoids problems with web instability by supporting the paper web along its entire path through the apparatus. Delays in parent roll production are reduced by alternating between multiple reeling apparatuses so that any one apparatus is winding paper web onto a parent roll while the others are swapping a completed parent roll for a new empty reel shaft. The reduction in down time due to reel switching allows for the production of small rolls which are easier to wind and handle.

A paper web manufacturing machine includes a wet section having a former for forming a wet web, a drying section for drying the wet web, and the multi-reel apparatus for winding the dried web into completed rolls. The multi-reel apparatus includes a web support which supports the travelling web along a path of travel that extends from a first vertical level to a second vertical level, wherein the two levels are vertically spaced. First and second reeling stations are located, respectively, at the first and second vertical levels. Each reeling station has a reeling device operable to hold and rotatably drive a core onto which the web is wound to form a roll. The reeling devices are further operable

to move the core into engagement with the web on the web support thereby initiating winding of the web onto the core. The reeling devices are also operable to move the core away from the web support when the roll is fully wound so that the web can begin winding onto the core held in the reeling device of the other reeling station. In this manner, the web is continuously wound alternately in one reeling station and then in the other reeling station. This increases the efficiency of the papermaking process by eliminating the down-time during reel switching.

In another embodiment, the continuous web prior to winding is divided into two partial-width web portions. Each reeling station includes two reeling devices spaced in the width direction of the web for the simultaneous winding of the two web portions. The continuous web is alternately wound in the two reeling devices of the first reeling station and then in the second reeling station. The partial-width web portions are advantageously wound onto separate cores and shafts at each station to form small rolls that are easily manipulated in additional downstream processing. The small rolls generally have lighter cores and shafts, and can even use composite based shaftless cores for an additional reduction in weight and an increase in reeling speed.

In yet another embodiment, the partial-width web portions are simultaneously wound in the first and second reeling stations into small rolls. Each reeling station includes first and second reeling devices that are vertically stacked whereby each web portion is continuously wound alternately in the first and then the second reeling devices of each reeling station.

Initiation of a new roll preferably is aided by a cutting device operable to sever the web when the roll in one of the reeling stations is completed so that the other reeling station can begin to wind the web onto its core. The cutting device may be combined with an adhesive applicator positioned adjacent to the path of travel of the web and upstream of the reeling stations. A signal triggers the adhesive applicator to apply adhesive to the web and the cutting device cuts the web so that the cut is downstream of the applied adhesive.

The web support in some embodiments comprises an endless carrying clothing guided along the path of travel by a plurality of rolls about which the clothing is looped. This clothing may be a through-air drying fabric on which the web is dried in the drying section, or it may be a separate clothing that receives the web from the drying section. Alternatively, the web support may comprise a foil or plurality of foils for supporting the web thereon.

The multi-reel apparatus has several advantages. The elimination of down time for reel switching allows for continuous paper web production and the cost-effective production of small rolls in place of jumbo rolls. Small, relatively light rolls reduce winding and downstream handling problems associated with heavy jumbo rolls. Lighter reel shafts used in smaller rolls are more easily controlled by the reeling device to maintain proper web tension and nip load for high quality tissue paper web production. In addition, the multi-reel apparatus does not require lowering arms or any mechanisms for moving a new reel shaft on which winding is commencing from an initial winding position into a final winding position previously occupied by the prior-wound roll. This further improves the simplicity of operation as well as the control of the nip load.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a schematic diagram that depicts a paper machine including a multi-reel apparatus in accordance with the present invention;

Figure 2 is a schematic diagram of the multi-reel apparatus shown in Figure 1 that depicts core replacement at the first reeling station;

Figure 3 is a schematic diagram of the multi-reel apparatus shown in Figure 1 that depicts the completed parent roll positioned for lift-off at the first reeling station;

Figure 4 is a schematic diagram of the multi-reel apparatus shown in Figure 1 that depicts the initial winding of a new roll at the first reeling station during removal of a completed parent roll at the second reeling station;

Figure 5 is a schematic diagram of the multi-reel apparatus shown in Figure 1 that depicts core replacement at the second reeling station;

Figure 6 is a schematic diagram of a multi-reel apparatus that depicts switching between winding at a second reeling station to winding at a first reeling station;

Figure 7 is a schematic diagram of the multi-reel apparatus shown in Figure 6 that depicts placement of a new core at the second reeling station during winding of the parent roll at the first reeling station;

Figure 8 is a schematic diagram of the multi-reel apparatus shown in Figure 6 that depicts switching between winding at the first reeling station to winding at the second reeling station;

Figure 9 is a schematic diagram that depicts a backward leaning multi-reel apparatus;

Figure 10 is a schematic diagram that depicts a multi-reel apparatus with three reeling stations;

Figure 11 is a schematic diagram that depicts a multi-reel apparatus wherein the direction of travel of the paper web has been reversed relative to that in Figures 1-10;

Figure 12 is a schematic diagram that depicts a paper web drying section including a Yankee dryer which has been bypassed for rebuilding;

Figure 13 is a schematic diagram that depicts a paper web drying section including a pair of stacked through-air dryers (TADs);

Figure 14 is a schematic diagram that depicts a paper web drying section with a shortened layout;

Figure 15 is a schematic diagram that depicts a paper web drying section with a flat layout;

Figure 16 is a schematic diagram that depicts a paper web drying section including the combination of a pair of TADs with a Yankee dryer;

Figure 17 is a schematic diagram that depicts a paper web drying section including a Yankee pre-dryer and a final TAD dryer;

Figure 18 is a schematic diagram that depicts a paper web drying section including a conventional Yankee dryer and a plurality of foils supporting the paper web;

Figure 19 is a schematic diagram that depicts a paper web drying section including a Yankee dryer with a dry-end wire for carrying the web from the Yankee to the multi-reel apparatus;

Figure 20A is a schematic diagram that depicts a multi-reel apparatus wherein each reeling station has a pair of adjacent reeling devices for reeling small rolls;

Figure 20B is an elevation view of the multi-reel apparatus of Figure 20A;

Figure 21A is a schematic diagram that depicts a multi-reel apparatus wherein each reeling station has a pair of vertically stacked reeling devices for reeling small rolls; and

Figure 21B is an elevation view of the multi-reel apparatus of Figure 21A.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will

fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

A first embodiment of a multi-reel apparatus **101** is shown in Figure **1** as part of a paper machine having a forming section **132** and a drying section **102**. Figures **2** through **8** depict two embodiments of the multi-reel apparatus **101** during different phases of operation. The forming section **132** includes an inner forming fabric **112**, an outer forming fabric **125**, a headbox **103**, and a forming roll **115**. The headbox **103** deposits an aqueous suspension of papermaking fibers between the inner fabric **112** and the outer fabric **125** as they traverse the forming roll **115**. The outer forming fabric **125** diverges from the inner forming fabric after the fabrics depart from the forming roll **115**. The paper web **108** is then carried on an underside of the inner forming fabric **112**.

The inner forming fabric **112** also comprises a drying fabric carrying the web **108** through the drying section **102**. More particularly, the paper web **108** is carried on the forming and drying fabric **112** through a pair of through-air dryers (TADs). The TADs **104** each include a drying cylinder **118** partially surrounded by a hood **119** which is connected to a blower (not shown). The fabric **112** with the paper web **108** supported thereon is guided around the pair of drying cylinders **118**. The drying cylinders **118** have outer surfaces that are air permeable and allow the passage of air, as shown by arrows **120**, through the paper web **108**, the fabric **112** and through the drying cylinder's permeable outer surface. The pressure of the air on the paper web **108** secures it against the fabric **112** in opposition to centrifugal forces. The choice of two TADs **104** is not meant to be restrictive, as a single TAD, several TADs, or other drying devices could be used to dry the paper web **108**.

The fabric **112** in the current embodiment also supports the web **108** through the multi-reel apparatus **101**. Thus, downstream of the TAD units a portion of the loop of fabric **112** travels upwards past a first reeling station having a first reeling device **110** at a first elevation and then past a second reeling station having a second reeling device **110'**, at a second, higher elevation. The paper web **108** is transferred from the fabric **112** to

whichever reeling device **110** or **110'** is currently winding the web onto a core **109**. A more detailed description of the multi-reeling apparatus **101** appears below.

Many advantages of the current invention will be apparent from a detailed description of the multi-reel apparatus **101**. The multi-reel apparatus includes the first reeling device **110** and the second reeling device **110'** positioned at different vertical levels along a portion of the loop of the forming and drying fabric **112**, allowing continuous winding of the paper web **108** because one of the pair of reeling devices is engaged with the web support assembly at all times. The pair of reeling devices **110** and **110'** alternate between winding and core switching roles, as shown in Figures **2** through **5**, to prevent interruption of the winding process.

Each reeling device **110**, **110'** includes a pair of carriages **122** each of which slides along one or more carriage rails **123** toward and away from the fabric **112** and is configured to support one of the cores **109** in a position proximate a pair of paper roll support rails **123**. The pair of rails **123** for the second reeling device **110'** are mounted at a greater height than those for the first reeling device **110**. The difference in vertical height places the carriage **122** of the first reeling device **110** further upstream along the fabric **112** than the carriage **122** of the second reeling device **110'**. Each carriage **122** is driven toward and away from the fabric **112** along the rails **133** by a hydraulic actuator (not shown). Two guide rolls **126** and **127** bracket a fabric run **128** of the fabric **112** that extends above and below the first and second reeling devices.

The web **108** is supported by the fabric **112** along the fabric run **128** between the two support rolls **126** and **127** and is wound onto a roll **111** rotatably supported by one of the reeling devices. The core **109** can be moved toward and away from the fabric **112** by the carriage **122**. As the parent roll **111** builds, the core **109** is continually moved away from the fabric to compensate for the increasing diameter of the roll. Movement of the carriage **122** can also be controlled to control a nip load between the paper roll and the fabric **112**. One suitable method for controlling nip load in this fashion is described in U.S. Patent Number 5,901,918, hereby incorporated herein by reference.

Continuous winding is achieved by alternating reel-up operation between the first and second reeling devices **110** and **110'**. Figures **2** and **3** show the second reeling device **110'** having completed a parent roll **111** and ready for switching. The switching process is aided by the tail cutter **106** which includes two nozzles, one to spray a water jet, and another to spray a glue jet, across a transverse section of the traveling web **108**. Once the parent roll **111** is near completion, the controller signals the tail cutter **106** to cut a section of the paper web **108** transverse to its direction of travel using the water jet. Simultaneously, or shortly thereafter, the glue nozzle sprays a glue jet slightly upstream from the severed edge of the paper web **108**. Advantageously, the water and glue nozzles are mounted for traversal in a cross-machine direction along the width of the paper web **108** and preferably can be mounted in the same traversing mechanism (not shown).

The first reeling device **110** advances a new core **109** into contact with the paper web **108** on the fabric **112** before the glue line is applied to the paper web **108** or before the glue line reaches the first reeling device. At the same general time, the second reeling device **110'** moves the nearly completed parent roll **111** away from the fabric **112**. As the paper web **108** continues to advance, the portion of the paper web downstream of the cut becomes the tail end of the current parent roll **111**. This downstream portion continues to be wound to completion on that parent roll by the second reeling device **110'**. The portion of the paper web upstream of the cut, containing the glue line, advances along the fabric **112** until it encounters the outside surface of the core **109** that is currently held by the first reeling device **110**. The glue line causes the upstream portion of the paper web to adhere to the core **109** of the second reeling device **110'**, thereby beginning a new parent roll **111'**, as shown in Figure **4**.

The completed parent roll **111** at the second reeling device **110'** is preferably rolled along the guide rails **123** by the carriage **122** to a pick-up location, keeping the movement and position of the roll under control. Alternatively, the roll **111** could be kicked off the carriage to roll along the guide rails **123**. The completed parent roll **111**

can be lifted from the rails **123** in any suitable manner (e.g., by using a traversing crane) for further distribution.

As shown in Figure **5**, the situation has reversed itself in that a new core **109** is being advanced into a position in contact with the fabric **112** at the second reeling device **110'**. The new core **109** is loaded onto the carriage **122** of the second reeling device **110'** and advanced toward the fabric **112**. Meanwhile, the first reeling device **110** continues winding of the core **109** into a parent roll **111** using the first reeling device **110**. Once the parent roll **111** approaches completion on the first reeling device **110**, the tail cutter **106** is triggered (as shown for another embodiment in Figure **8**). The paper web **108** is cut and glued by the tail cutter **106** with the downstream portion becoming the tail end of the parent roll **111** at the first reeling device **110** and the upstream portion (with the glue line) adhering to the core **109** held by the second reeling device **110'**. Before wind-up at the second reeling device **110'** commences, the first reeling device **110** has performed its kick-off operation. In this manner, the multi-reel apparatus **101** can continue the winding process indefinitely and without interruption. No delay is encountered while switching out completed rolls for new cores. Furthermore, the paper web at all times is supported on the fabric **112** during winding.

Note that variations are possible for the commencement of a new roll **111'** beyond the use of the tail cutter **106**. In one embodiment, the web **108** is severed by kicking the fully wound roll away from the fabric **112** to cause a rapidly imposed tensile force on the web. One or more air jets serve to blow the paper web back toward the new core after it has been severed by the kick-out procedure. The paper web is then captured by vacuum suction from within the core. In another embodiment, glue could be applied directly to the new core so that contact with the paper web commences reel-up and simultaneously tears the web thereby allowing completion of the old parent roll.

A range of other embodiments of the multi-reel apparatus **101** are also possible. The flexibility inherent in the multi-reel **101** invention is important due to the fact that in many situations it may be retrofit to a preexisting paper machine. Paper machines are

often custom built to meet the user's desired paper type and quality. In addition, each user is operating under unique space and cost constraints that will, in part, dictate the layout of the paper machine (such as whether portions of the machine are above or below a main floor **200**). Existing machines can have any number of dryers in varying arrangements and still benefit from continuous winding as performed by the multi-reel **101**. The following description of alternative embodiments is only intended to be demonstrative of the flexibility of this invention and not limiting in any way.

Figures **6** through **8** show another embodiment of the multi-reel apparatus **101** wherein the fabric **112** extends horizontally out from the top guide roll **127**. Figure **6** depicts completion of the parent roll **111** at the second reeling device **110'**. Figure **7** depicts kick-out of the completed parent roll **111** and core **109** replacement at the second reeling device **110'** while winding of the new roll **111'** continues at the first reeling device **110**. Figure **8** depicts engagement of the core **109** with the fabric **112** at the second reeling device **110'** as winding of the parent roll **111** is completed at the first reeling device **110**.

Figure **9** shows an embodiment of the multi-reel apparatus **101** wherein the fabric run **128** is backward leaning. In this embodiment, the first and second reeling devices **110** and **110'** are nearly vertically aligned. This cuts down on the horizontal space needed for the multi-reel apparatus **101**. Note that the fabric run **128** could also be vertical or slightly forward leaning and still achieve near vertical alignment.

Figure **10** presents an embodiment wherein the multi-reel **101** comprises an additional third reeling device **110''**. The first reeling device **110**, the second reeling device **110'** and the third reeling device **110''** are all vertically stacked at different vertical levels. One advantage is that this allows greater cycle times for a given reeling device which allows more time for the kick-out and removal of parent rolls **111** and/or the placement of new cores **109**. Another advantage is that maintenance could be performed on any one of the reeling devices **110**, **110'** and **110''** while the others continue normal operation.

Figure **11** schematically depicts another embodiment wherein the direction of travel of fabric **112** and paper web **108** has been reversed. In this embodiment, the upper or second reeling device **110'** is upstream of the lower or first reeling device **110**. Figure **12** depicts another embodiment wherein a pre-existing drying section **102** has been retrofit to bypass a Yankee dryer **129** and substitute through-air drying. Note also that this embodiment includes a separate inner forming fabric **130** from which the web **108** is transferred onto the drying fabric **112**.

Figure **13** schematically depicts an embodiment wherein the TADs **104** are stacked instead of adjacent which reduces the footprint of the drying section **102**. The top TAD **104** is an outward-flow unit indicated by the arrows **120**. The paper web **108** through the top TAD is on the inside of the fabric **112**, against the drying cylinder **118**. The bottom TAD is an inward flow unit having the fabric **112** between the web and the drying cylinder **118**.

Figure **14** depicts an embodiment with a layout shortened by use of the backward leaning fabric run **128** for the multi-reel **101** similar to Figure **9**, but at a steeper angle, such that a part of the multi-reel is directly above the drying section **102**. In this embodiment, the multi-reel apparatus **101** is located above and supported by the main floor **200**. The TADs **104** are located below the main floor **200**.

Figure **15** depicts an embodiment using two outward flow TADs **104** that have their hoods **119** above, rather than below, the drying cylinders **118**. This embodiment advantageously eliminates the requirement of space below the main floor **200**. The forming section **132**, the TADs **104** and the multi-reel apparatus **101** are all located above and supported by the main floor **200**.

Figure **16** depicts an embodiment with a combination of TADs **104** located below the main floor **200** and a Yankee dryer **129** located above the main floor. After being creped from the Yankee dryer **129**, the web **108** is received by a support clothing **112'** that carries the web through the multi-reel apparatus **101** which is located below the main floor **200**.

Figure **17** depicts a machine having two TADs **104** located below the main floor **200** and a Yankee dryer **129** located above the main floor performing a pre-drying operation. The final drying is performed by an additional TAD **104** whose drying fabric **112** carries the web through the multi-reel apparatus. The second reeling device **110'** is also located above the main floor **200**, while the first reeling device **110** is located below the main floor.

Figure **18** depicts an embodiment wherein the web **10** is supported through the multi-reel apparatus **101** by a plurality of foils **131**. Figure **19** depicts an embodiment similar to that of Figure **16** but having only a Yankee dryer for drying the web.

In another embodiment, the tissue paper web **108**, which in many cases may be 5 to 6 meters in width, is cut in the middle prior to reel-up to create two small rolls **111A** and **111B** that are approximately half the original width of the paper web. Two separate, partial-width web portions **108A** and **108B** are simultaneously wound onto separate cores **109A** and **109B**, respectively, to form the small rolls **111A** and **111B**. In one embodiment, as shown in Figures **20A** and **20B**, the first reeling station includes a pair of small roll reeling devices **210** positioned at different vertical levels, and spaced in the cross-machine direction. The second reeling station includes another pair of small roll reeling devices **210'** positioned in an arrangement similar to that of the first reeling station. The adjacent arrangement allows the simultaneous winding of the split web portions **108A** and **108B** in the same reeling station. Continuous winding is achieved by alternating between each pair of small roll reeling devices **210** and **210'**.

In another split web embodiment, as shown in Figures **21A** and **21B**, the first reeling station includes two alternately operable reeling devices **210** for winding one of the partial-width web portions, and the second reeling station includes two alternately operable reeling devices **210'** for winding the other web portion. The vertical stacking arrangement allows the simultaneous winding of the split web portions **108A** and **108B** in different reeling stations. Continuous winding is achieved by alternating between the small roll reeling devices of each pair of reeling devices **210, 210'**. In general, smaller

rolls are easier to handle in downstream operations than the heavier jumbo rolls. Nip loads are easier to handle with small rolls, contributing to the production of high-quality tissue paper. The smaller rolls also allow the use of composite based shaftless cores such as those described in commonly owned U.S. Patent Application No. 60/214,504 filed June 28, 2000.

Note that additional embodiments of the present invention where the layout of the above-listed embodiments are inverted or in mirror image, are also possible. Although preferred for the manufacture of tissue paper webs, the multi-reel apparatus of the present invention could also be used with other paper grades.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.